United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 1-34
● Original
Amendment

Contract Number: EP-C-09-027	Contract Period Base: 04/01/2010 - 03/31/2011 Option Period No. 1	SF Site Name:

Title of Work Assignment: Environmental Impacts of Fast Pyrolysis for Biocrude Production.

Suggested Source: Arcadis	Specify Section & Paragraph of Contract SOW:
Purpose: ● Work Assignment Initiation ○ Work Assignment Amendment ○ Work Plan Approval ○ Work Assignment Close-Out ○ Incremental Funding	Period of Performance From: 06/08/2010 To: 03/31/2010
Comments: New Work Assignment	QA Category (check one) I Enforcement II Standard Setting III Technology Development ● IV Proof of Concept N/A

Note: To report additional accounting and appropriations data use EPA Form 1900-69A.

SFO 22 (Max 2) Superfund

Accounting and Appropriations Data

Non-Superfund

	DCN (Max 6)	Budget/FYs (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount	Sites/Project (Max 8)	Cost Org/Code (Max 7)
1									
2									
3									
4									
5									

Authorized Work Assignment Ceiling

Contract Period:	Cost/Fee	LOE
Previously Approved	New	
This Action		
Total		

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

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Contractor Acknowledgement & Receipt and Approval of Workplan (Signature and Title) | Date

Statement of Work
for
Environmental Impacts of Fast Pyrolysis for Biocrude Production

Project Description

Efforts have been undertaken by the industry and government to develop innovative biomass fast pyrolysis processes to produce biocrude cost-effectively. Biomass fast pyrolysis produces much higher liquid yield (~75%) compared to that (~5%) from biomass gasification. Another major advantage of the fast pyrolysis process followed by biocrude refining is that this route consumes much less energy than the other conventional thermochemical routes. The pyrolysis process can be located close to the sources of biomass feedstock and the resulting biocrude with much higher energy than that of the feedstock can be shipped to a biorefinery to improve overall energy efficiency and reduce the transportation energy and also costs of the fast pyrolysis/biocrude upgrading route. The fast pyrolysis biofuel production pathway is currently under intensive research and development. But the potential environmental and health impacts on air emissions and other environmental media as a result of the deployment of a large number of widespread, small-scale biomass pyrolysis units need to be understood. The wide range of products, including gases, liquids, and solids produced from pyrolysis, have different physical and chemical characteristics that could also impact the environment and human health. A project is initiated to investigate the potential environmental and health consequences of the biomass fast pyrolyis process for biocrude production.

Objective

The potential environmental and human health impacts of the biomass fast pyrolysis technology will be evaluated in this in-house project. The gaseous, liquid, and solid products produced from the pyrolysis process will be characterized and assessed for their potential environmental and human health effects. Information important for understanding the environmental consequences concerning the process such as air emissions, toxicity of the products and by-products/wastes generated, are not available. Furthermore, the use of special chemicals in the process to promote conversion of biomass into more desirable liquid products may create significant challenge on existing air emissions control systems and waste management practices. Data generated by this project is also important for assessing the applicability of existing air emissions control systems and waste management practices for reducing the process's potential environmental concerns.

Approach

This in-house research project will evaluate the effects of changes in biomass feedstock (e.g., agricultural waste and forest residue) and fast pyrolysis conditions on the release of pollutants to the environment and their associated potential human health impacts. The work includes building a bench-scale flow reactor for simulating biomass fast pyrolysis conditions. This reactor will be used by APPCD to perform biomass fast pyrolysis experiments and characterize the products for their environmental and potential human health consequences. Experiments will be

designed to simulate conditions of commercial and emerging fast pyrolysis processes. The gaseous products produced from the pyrolysis experiments will be characterized by using gas chromatography (GC). The condensable liquid, containing significant amounts of oxygenated hydrocarbons with potentially toxic components such as endocrine disruption compounds (EDCs), will be characterized by solvent fractionation followed by GC/MS analysis of the different fractions.

The characteristics of the gaseous, liquid, and solid products obtained from chemical analysis of these products will be evaluated for their potential environmental and human health effects. Another approach of this research will be to conduct bioassay-directed chemical analysis experiments using a cell line stably expressing an estrogen-responsive reporter gene and to screen compounds responsible for estrogenic activity. Although the in vitro assay provides information on the cumulative response of estrogenic activity, the amount of contribution from specific substances cannot be determined. The use of both in vitro bioassay and instrumental analysis will be useful for the identification and characterization of estrogenic activity in the liauid samples. Both the gas phase and solid phase products will also be assessed for toxicity via inhalation exposure studies in mice. Comparative toxicity and dose response profiles will be developed for the different fuel types and under various pyrolysis process conditions. Liquid products bioassay work will be conducted by an APPCD researcher, and the inhalation exposure studies in mice will be carried out by a researcher from the National Health and Environment Research Lab. These health effect studies are not included in the scope of this work assignment.

Statement of Work

TASK 1. Work Plan, Reporting, Budget, And WA Management

The contractor shall prepare and deliver to the WA manager (WAM) a work plan and budget within 20 days of WA effective date. The work plan shall include a description of how the contractor shall accomplish each task, along with a breakdown, per task, level of effort by professional level, a cost breakdown, and any underlying assumptions used. The contractor shall conduct activities necessary to manage the WA, including at least weekly communication with the EPA WAM. The contractor shall prepare a Quality Assurance Project Plan (QAPP) as specified in Attachment #1. Work involving environmental data shall not commence until the QAPP has received official approval from the EPA Quality Assurance Staff. The contractor shall comply with all requirements as delineated on the "Quality Assurance Review Form" included with this WA.

TASK 2. Design and Installation of the Fast Pyrolysis Reactor System

The contractor shall assist in the design and installation of a reactor system which will be used for pyrolyzing biomass samples under fast pyrolysis process conditions (~500 ^{o}C, <2 s cooling time). The reactor will be located in the highbay building (H-106). The system shall be designed and installed by the contractor for processing several hundred grams of biomass sample per hour. The system size needs to be optimized for generating enough pyrolysis product samples for evaluating their potential environmental impacts. The system includes three major components: the feeder unit, reactor, and pyrolysis products separation and collection devices. A feeder unit shall be designed and installed for feeding biomass sample to the reactor under a controlled and steady feed rate. The reactor with an inert surface is heated externally by an electrical furnace. Temperature of the reactor needs to be maintained at a constant temperature which is monitored continuously by

a control unit which also includes a data acquisition system (DAS). Inert nitrogen (N_2) gas is used to provide the oxygen-free environment inside the reactor for pyrolysis reactions to proceed. A mass flow controller is used for controlling the N_2 gas flow into the reactor. Special attention shall be paid by the contractor for the leak proof design of the reactor system in order to prevent air is leaking into the reactor to cause combustion instead of pyrolysis of the biomass sample inside the reactor. A hot cyclone and high temperature filter shall be designed and installed near the outlet of the heating (or reaction) zone of the reactor to remove particulate matter (PM) generated by the pyrolysis reactions. The collected PM sample will be assessed for toxicity via inhalation exposure studies in mice by a researcher from the National Health and Environment Research Lab. These health effect studies are not included in the scope of this work assignment. A rapid cooling device shall be designed and installed for cooling the hot gas leaving the reactor quickly (<2 second) to room temperature. All condensable liquids produced from the pyrolysis process are collected quantitatively in the device for further evaluation of their toxicity by an APPCD researcher. The toxicity evaluation studies are not included in this work assignment. The temperature of the filtered and cooled product gas stream is monitored via the DAS before it is pulled through a continuous emission monitoring (CEM) consisting four gas analyzers to measure the concentrations of CO, CO_2, O_2 and total hydrocarbon (THC) separately in the stream. APPCD's existing gas chromatograph (GC) which is equipped with a thermal conductivity detector (TCD) shall be used to measure concentrations of H_2, CO, CH_4, and CO_2 in the stream from a 0.5 ml sample loop.

TASK 3 Biomass Fast Pyrolysis Experiments

Experimental studies shall be conducted to collect and analyze gaseous, liquid, and solid products produced as a function of input biomass fuel type and pyrolysis operating parameters using the reactor system built in Task 2. The system shall be operated according to design specifications and establish operating conditions for producing fast pyrolysis products. Characterization of the products produced during fast pyrolysis of the finely grinded biomass samples is the major objective of the experiments. This characterization shall provide data that shall be used to set operating parameters, such as biomass and inert gas (N_2) feed rates and corresponding product gas characteristics. Quantities to be measured include N_2 and biomass feed rates, reactor and outlet gas temperatures, solid and liquid product collection rates, concentrations of CO, CO_2, O_2, THC, H_2, and CH_4 in the non-condensable gas product. The contractor shall deliver raw analytical data (computer files and data sheets) and reduced data in the form of Excel spreadsheets, pie charts, and graphs of the data collected for each experimental study.

Operation of the Fast Pyrolysis Reactor (FPR) System

A QAPP shall be prepared by the contractor for this particular Task. The contractor shall not begin data collection until the QAPP is provided by EPA Quality Assurance Staff. The contractor shall assist in the operation of the Fast Pyrolysis Reactor System. This shall include but not be limited to: finely grinded biomass samples such as wood chips, agricultural waste, and forest residues.

Products Sampling and Analysis

The contractor shall provide support and expertise in vapor-phase sampling for product gas. This shall include, but not be limited to CO, CO_2, O_2 and THC measurements taken with continuous emission monitors (CEMs), and H_2, CO, CH_4, and CO_2 measurements by GC. The contractor shall also provide support and expertise on sampling and characterization of other products which shall be included but not limited to PM and condensable liquids.

Maintenance and Repair of FPR System

The contractor shall provide the labor necessary to maintain and repair the PFR including the associated gas supply equipment and other auxiliary equipment. Examples include repairing glassware, calibrating nozzles, thermocouples, mass flow controllers, CEMs, GC, tracking equipment inventories, etc. Conduct of specific actions shall be approved in writing by the WAM prior to initiation of any identified support action.

Purchasing of Expendable Supplies

The contractor shall be responsible for purchasing general expendable supplies required to maintain operation of the FPR. The WAM shall provide approval for any purchases related to the supplies listed below.

These supplies shall include, but not be limited to:

a) Calibration, supply and carrier gases for analytical systems
b) Valves, tubing and piping
c) Compression fittings
d) Biomass samples
e) Chemicals and reagents
g) Sorbent tubes and other gas-sampling consumables

Deliverables and Reports of Work

The contractor shall prepare a work plan and budget within 20 days of WA effective date. The contractor shall prepare and submit monthly reports in accordance with the terms and conditions of the contract. The contractor shall complete the installation of the fast pyrolysis reactor as required by Task 2 within 90 days of WA effective date. The Preliminary results of the pyrolysis experiments as required by Task 3 shall be delivered by the contractor within 180 days of WA effective date.

The contractor shall prepare, as requested by WAM, data summary, project progress reports, briefing materials, presentation for technical meetings/conferences, and paper submitting to peer reviewed journals. The contractor shall coordinate with the WAM to ensure compliance with NRMRL/APPCD policies and guidelines concerning review and approval of technical papers and reports. Technical papers and presentations will be co-authored with EPA researchers.

The contractor shall maintain at least weekly communications with the WAM. Additionally the contractor shall inform the PO and the WAM in writing when 75% of the total funds and/or hours contained in the work plan are expended.

Quality Assurance/Quality Control

The contractor shall prepare a Quality Assurance Project Plan (QAPP) as required in Attachment #1 to the Statement of work for "Environmental Impacts of Fast Pyrolysis for Biocrude Production." After preparation, the QAPP shall be reviewed and approved by the ARCADIS work assignment leader and QA officer. Once it has obtained their approval, it shall be submitted to the EPA QA staff for review and approval. It shall be accompanied by a signature page that is signed by the ARCADIS work assignment leader and QA officer to show that they have reviewed and

approved the QAPP. It is the responsibility of the ARCADIS work assignment leader to document this process. Upon receipt of the signed QAPP, the EPA work assignment manager and QA manager will review and approve the QAPP and they will add their signatures to the signature page. Any work involving environmental data shall not commence until the QAPP has received official approval from the EPA QA staff.

ATTACHMENT #1 TO THE STATEMENT OF WORK (SOW) FOR MEASUREMENT PROJECTS

NRMRL Quality Assurance (QA) Requirements

In accordance with EPA Order 5360.1 A2, conformance to ANSI/ASQC E4 must be demonstrated by submitting the quality documentation specified herein. All quality documentation shall be submitted to the Government for review. The Government will review and return the quality documentation, with comments, and indicate approval or disapproval. If the quality documentation is not approved, it must be revised to address all comments and shall be resubmitted to the Government for approval. Work involving environmental data collection, generation, use, or reporting shall not commence until the Government has approved the quality documentation. The quality documentation shall be submitted to the Government at least thirty (30) days prior to the beginning of any environmental data gathering or generation activity in order to allow sufficient time for review and revisions to be completed. After the Government has approved the quality documentation, the Contractor shall also implement it as written and approved by the Government. Any EPA-funded project/program may be subject to a QA audit.

TO BE SUBMITTED PRE-AWARD (mark all that apply):

□ **NRMRL's Quality System Specifications:**

(1) a description of the organization's Quality System (QS) and information regarding how this QS is documented, communicated and implemented;
(2) an organizational chart showing the position of the QA function;
(3) delineation of the authority and responsibilities of the QA function;
(4) the background and experience of the QA personnel who will be assigned to the project; and
(5) the organization's general approach for accomplishing the QA specifications in the SOW.

□ **Quality Management Plan:** prepared in accordance with R-2 - EPA Requirements for Quality Management Plans (EPA/240/B-01/002) March, 2001, http://www.epa.gov/quality/qs-docs/r2-final.pdf

TO BE SUBMITTED POST-AWARD (mark all that apply):

□ **NRMRL's Quality System Specifications:**

(1) a description of the organization's Quality System (QS) and information regarding how this QS is documented, communicated and implemented;
(2) an organizational chart showing the position of the QA function; 07/14/08 A-2
(3) delineation of the authority and responsibilities of the QA function;
(4) the background and experience of the QA personnel who will be assigned to the project; and
(5) the organization's general approach for accomplishing the QA specifications in the SOW.

□ **Quality Management Plan:** prepared in accordance with R-2 - EPA Requirements for Quality Management Plans (EPA/240/B-01/002) March, 2001, http://www.epa.gov/quality/qs-docs/r2-final.pdf

□ **Category I or II Quality Assurance Project Plan (QAPP):** prepared in accordance with R-5 - EPA Requirements for QA Project Plans (EPA/240/B-01/003) March, 2001 http://www.epa.gov/quality/qs-docs/r5-final.pdf

X **Category III or IV QAPP:** prepared in accordance with applicable sections of the following NRMRL QAPP Requirements List(s) which is(are) included in this attachment:

X **QAPP Requirements for Measurement Projects**

□ **QAPP Requirements for Secondary Data Projects**

□ **QAPP Requirements for Research Model Development and/or Application Projects**

□ **QAPP Requirements for Software Development Projects**

□ **QAPP Requirements for Method Development Projects**

□ **QAPP Requirements for Design, Construction, and/or Operation of Environmental Technology Projects**

ADDITIONAL QA RESOURCES:

EPA's Quality System Website: http://www.epa.gov/quality/
EPA's Requirements and Guidance Documents: http://www.epa.gov/quality/qa_docs.html

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NRMRL QAPP REQUIREMENTS FOR MEASUREMENT PROJECTS

GENERAL REQUIREMENTS:

Include cover page, distribution list, approvals, and page numbers.

0. COVER PAGE

Include the Division/Branch, project title, revision number, EPA technical lead, QA category, organization responsible for QAPP preparation, and date.

1. PROJECT DESCRIPTION AND OBJECTIVES

1.1 Describe the process and/or environmental system to be evaluated.
1.2 State the purpose of the project and list specific project objective(s).

2. ORGANIZATION AND RESPONSIBILITIES

2.1 Identify all project personnel, including QA, and related responsibilities for each participating organization, as well as their relationship to other project participants.
2.2 Include a project schedule that includes key milestones.

3. SCIENTIFIC APPROACH

3.1 Describe the sampling and/or experimental design that will be used to generate the data needed to evaluate the projective objective(s). A description of the design should include the types and numbers of samples (including QC and reserve samples), the design of the sampling network, sample locations and frequencies, and the rationale for the design.
3.2 Identify the process measurements (e.g., flow rate, temperature) and specific target analyte(s) for each sample type.
3.3 Describe the general approach and the test conditions for each experimental phase.

4. SAMPLING PROCEDURES

4.1 Describe any known site-specific factors that may affect sampling procedures as well as all site preparation (e.g., sampling device installation, sampling port modifications, achievement of steady-state) needed prior to sampling.
4.2 Describe or reference each sampling procedure (including a list of equipment needed and the calibration of this equipment as appropriate) to be used. Include procedures for homogenizing, compositing, or splitting of samples, as applicable.
4.3 Provide a list of sample containers, sample quantities to be collected, and the sample amount required for each analysis, including QC sample analysis.
4.4 Specify sample preservation requirements (e.g., refrigeration, acidification, etc.) and holding times.
4.5 Describe the method for uniquely numbering each sample.
4.6 Describe procedures for packing and shipping samples, including procedures to avoid cross-contamination, and provisions for maintaining chain-of-custody (e.g., custody seals and records), as applicable.

5 MEASUREMENT PROCEDURES

5.1 Describe in detail or reference each process measurement or analytical method to be used. If applicable, identify modifications to EPA-approved or similarly validated methods.
5.2 If not provided in Section 5.1 or the referenced method, include specific calibration procedures, including linearity checks and initial and continuing calibration checks.

6 QUALITY METRICS (QA/QC CHECKS)

6.1 For each process measurement and analytical method, identify the required QC checks (e.g., blanks, control samples, duplicates, matrix spikes, surrogates), the frequencies for performing these checks, associated acceptance criteria, and corrective actions to be performed if acceptance criteria are not met.
6.2 Any additional project-specific QA objectives (e.g., completeness, mass balance) shall be presented, including acceptance criteria.

7 DATA ANALYSIS, INTERPRETATION, AND MANAGEMENT

7.1 Identify the data reporting requirements, including data reduction procedures specific to the project and applicable calculations and equations.
7.2 Describe data validation procedures used to ensure the reporting of accurate project data.
7.3 Describe how the data will be summarized or analyzed (e.g., qualitative analysis, descriptive or inferential statistics) to meet the project objective(s).
7.3.1- If descriptive statistics are proposed, state what tables, plots, and/or statistics (e.g., mean, median, standard error, minimum and maximum values) will be used to summarize the data.
7.3.2- If an inferential method is proposed, indicate whether the method will be a hypothesis test, confidence interval, or confidence limit and describe how the method will be performed.
7.4 Describe data storage requirements for both hard copy and electronic data.

8 REPORTING

8.1 List and describe the deliverables expected from each project participant responsible for field and/or analytical activities.
8.2 Specify the expected final product(s) that will be prepared for the project (e.g., journal article, final report).

9. REFERENCES

Provide references either in the body of the text as footnotes or in a separate section.